

Paper

Computed Tomography Pulmonary Angiography: A Sample of Experience at a District General Hospital

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ABSTRACT

Purpose: Pulmonary embolism (PE) has a significant associated morbidity and mortality. The role of diagnostic imaging in PE is being increasingly undertaken by computed tomography pulmonary angiography (CTPA). An advantage of CTPA is its ability to simultaneously provide information on the lung parenchyma, mediastinum, pleural spaces, and chest wall. A sample of CTPAs was therefore reviewed to identify the types of additional pathology demonstrated.

Materials and Methods: One hundred and ninety-eight CTPA examinations were retrospectively reviewed. A record was made of the presence of PE and any additional pathology, with particular interest given to “incidental” pathology, or pathology that was unsuspected but which was significant enough to change the patient’s management. A note was also made as to the adequacy of the study. D-Dimer values were recorded when available.

Results: PE was demonstrated in 56 studies (28.3%). Additional pathology was seen in 112 studies (56.6%), of which 17 were categorised as incidental. These included multiple pulmonary nodules, solitary lung lesions, destructive bony lesions, pancreatitis, a solid renal mass, mesothelioma, reactivated pulmonary tuberculosis, recurrent bronchial carcinoma, pulmonary fibrosis, an SVC filling defect, and a compression fracture of T10.

Conclusion: The prevalence of PE in our sample was 28.3%, compared with a reported prevalence, mainly by pulmonary angiography, of between 19% and 79%. Secondary findings were found in 56.6% of scans, with completely incidental findings demonstrated in 17 patients (9%). This emphasizes the usefulness of CTPA in providing additional diagnostic information and alternative diagnoses in patients with suspected PE.

INTRODUCTION

Pulmonary embolism (PE) is a condition with a significant associated morbidity and mortality. The incidence of PE has been estimated at between 300,000 and 600,000 episodes per year in the US, with between 50,000 and 200,000 deaths occurring as a result^{1,2}. When the diagnosis is confirmed and treatment promptly initiated, the incidence of recurrence is reduced and death is infrequent.

The diagnosis of PE is fraught with difficulty. The presenting symptoms are non-specific and inconsistently present³. The clinical presentation may also be atypical or be masked by other coexistent disease. The use of a negative serum D-Dimer estimation combined with a low clinical probability score allows for identification of patients at low risk and in whom a diagnosis of PE can be excluded before imaging is required⁴.

The role of imaging in the diagnosis of PE is being increasingly undertaken by computed tomography pulmonary angiography (CTPA), which can demonstrate filling defects in segmental and subsegmental pulmonary arteries^{5,6}. The advent of multidetector-row CT (MDCT) allows for shorter image acquisition times and narrower collimation, facilitating isotropic data acquisition and reducing patient movement artefact. Multidetector-row CTPA has been shown

to have a sensitivity of 100% and a specificity of 89% in the investigation of patients with suspected PE, equivalent to or possibly higher than that of conventional pulmonary angiography⁷. CTPA is now included in guidelines for the management of PE in both the United Kingdom and United States of America, and patients with a good quality negative CTPA do not require further investigation or treatment for PE^{8,9}. It should be noted, however, that a number of factors can affect whether or not a CTPA is of good quality. These include issues relating to the patient, such as the ability to breath-hold during the study, and anatomical issues such as patient size, which may have a bearing on the signal to noise ratio of the acquired images. Technical problems can also reduce the quality of the study, and these might include issues relating to intravenous (IV) access, and to the timing of image acquisition, both of which could have a bearing on the opacification of the pulmonary arteries.

One of the advantages of CT over other imaging modalities is its ability to concurrently present information on the lung

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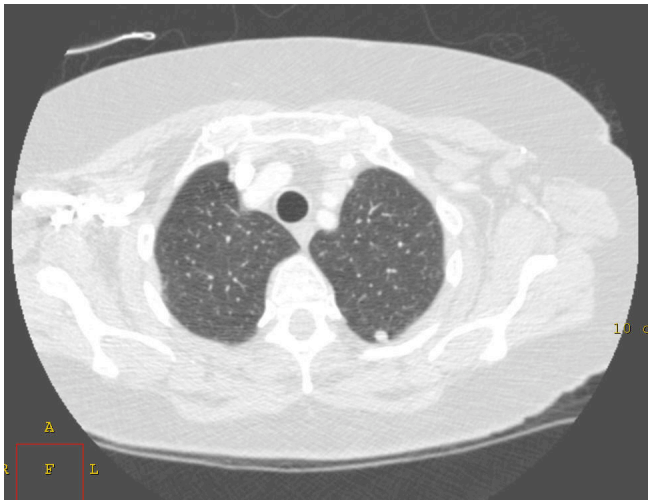


Fig 1a. Lung nodule demonstrated posteriorly in the left upper lobe.



Fig 1b. Lung nodule seen posteriorly in the right lower lobe.

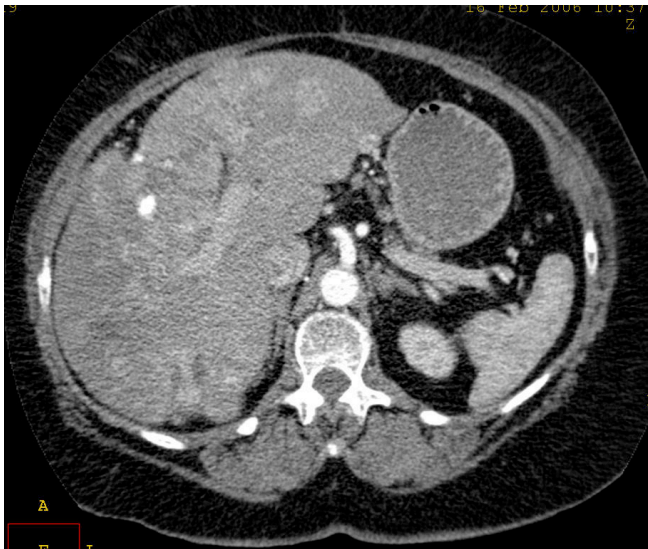


Fig 1c. In this patient the lung metastases were from a known hepatocellular carcinoma, seen as a rather diffuse abnormally enhancing mass within the liver.

TABLE I.
Other diagnoses commonly found.

Diagnosis	Frequency
Consolidation	45
Pleural Effusion	35
Chronic Bronchitis and Emphysema	13
Multiple Nodules	10
Lymphadenopathy	7
Cardiomegaly	6
Solitary Pulmonary Nodule	5
Bronchiectasis	4
Pulmonary Oedema	3

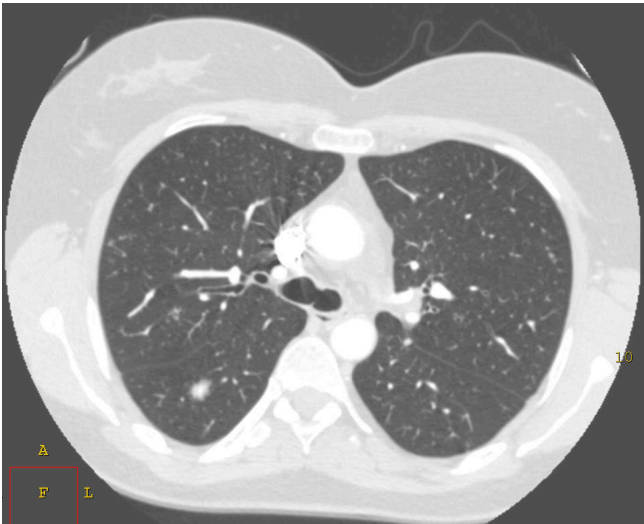


Fig 2a. Lung nodule identified in the apical segment of the right lower lobe.

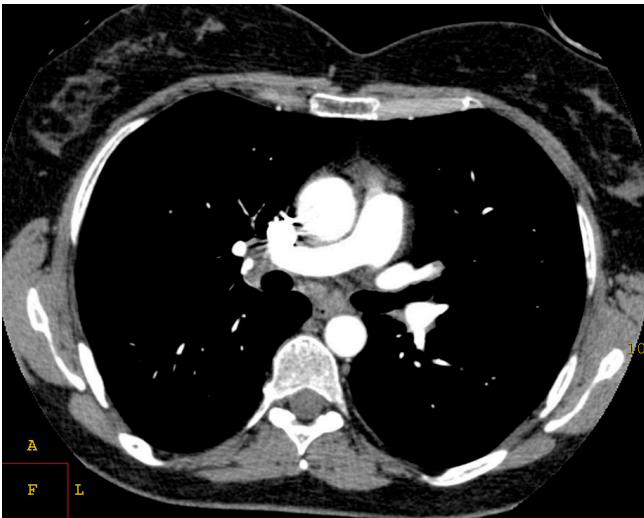


Fig 2b. Mediastinal lymphadenopathy in the subcarinal region of the same patient.

TABLE II.
Summary of findings categorised as incidental.

Incidental findings	No. of patients	Presumptive diagnosis
Multiple pulmonary nodules	4	Multiple metastases n = 3 (fig 1) Inflammatory nodules n = 1 (fig 2)
Solitary lung lesions	4	Bronchial carcinoma n = 4 (fig 3)
Destructive bony lesions and spiculated lung mass	1	Bony metastases (fig 4a) with primary lung carcinoma (fig 4b)
Peritoneal inflammatory disease	1	Pancreatitis, confirmed with additional scan range (fig 5)
Solid renal mass	1	Renal cell carcinoma (fig 6)
Nodular pleural thickening	1	Mesothelioma (fig 7)
Apical fibrosis, cyst formation and air fluid levels	1	Reactivated TB (fig 8)
Previous left pneumonectomy, right lung mass	1	Tumour recurrence (fig 9)
Prominent interstitial lung markings and cyst formation	1	Interstitial lung disease (fig 10)
Filling defect right atrium and superior vena cava	1	Confirmed by echocardiogram, patient died before diagnosis confirmed (fig 11)
Compression fracture 10 th thoracic vertebral body	1	Osteoporotic collapse (image not available)

parenchyma, mediastinum and pleural spaces, in addition to that provided on the pulmonary arteries. Therefore, part of the interpretation process includes assessment of these structures, as well as the visible bony skeleton and upper abdomen, to identify other pathologies which may be associated with PE or which may be incidental. For these reasons, a sample of CTPAs was reviewed to identify what types of additional pathology are identified and how frequently, in the setting of CTPA examinations for suspected PE.

METHODOLOGY

One hundred and ninety-eight CTPA examinations were retrospectively reviewed. These were performed between January and November 2006, at the Ulster Hospital, a district general hospital on the outskirts of Belfast, in Northern

TABLE III.
Reasons for limited adequacy of scan.

Reason	Number of Scans
Patient Movement	15
Technical Reasons	14
Patient Body Habitus	6
IV Access Problems	2
Valsalva manoeuvre	2

Ireland. The scanner used was a 16-slice Philips MX 8000 IDT 16 channel scanner. A record was made as to whether or not a PE was demonstrated and if any additional pathology was identified. A note was also made as to the adequacy of the study, and what factors contributed to an inadequate study. A D-Dimer value was noted if it had been available (normal range less than 250 nanograms per millilitre).

Any additional pathology demonstrated was recorded, with particular interest given to “incidental” pathology, or pathology that was completely unsuspected but which was significant enough to require a change in the patient’s management. Significant pathology, which was already known about, such as known metastatic lung disease, was noted but not categorised as incidental.

RESULTS

Of the 198 examinations performed, PE was demonstrated in 56 (28.3%). Other pathology was seen in 112 studies (56.6%), with the more common findings listed in table I. These included consolidation (n=45), pleural effusion (n=35), changes consistent with chronic obstructive pulmonary disease (COPD) (n=13), multiple pulmonary nodules (n=10), lymphadenopathy (n=7), cardiomegaly (n=6), solitary pulmonary nodules (n=5), bronchiectasis (n=4), and pulmonary oedema (n=3).

Seventeen findings categorised as incidental were demonstrated (8.6%). These are listed in table II.

One hundred and forty-seven patients had serum D-Dimer estimation performed during the admission in which they underwent CTPA. Results between 250 and 1000 were given a numerical value, with the remaining results given as “less than 250” or “greater than 1000”. None of the patients with a D-Dimer of less than 250 had a PE demonstrated on CTPA. PE was demonstrated in 31 of the 72 patients with a D-Dimer of greater than 1000 (43.1%). PE was demonstrated in 13 of the 64 patients whose D-Dimer levels were between 250 and 1000. A student’s t-test showed that difference between the D-Dimers for the PE and No PE groups, when they fell between 250 and 1000, was not statistically significant (P value 0.14).

Forty-nine scans (24.7%) were reported as at least technically adequate. A total of 36 scans (18.2%) were reported as suboptimal or inadequate, with the stated reasons, listed in table III, including patient movement (n=15), technical problems (n=14), patient body habitus (n=6), problems with IV access (n=2), or poor opacification of the pulmonary

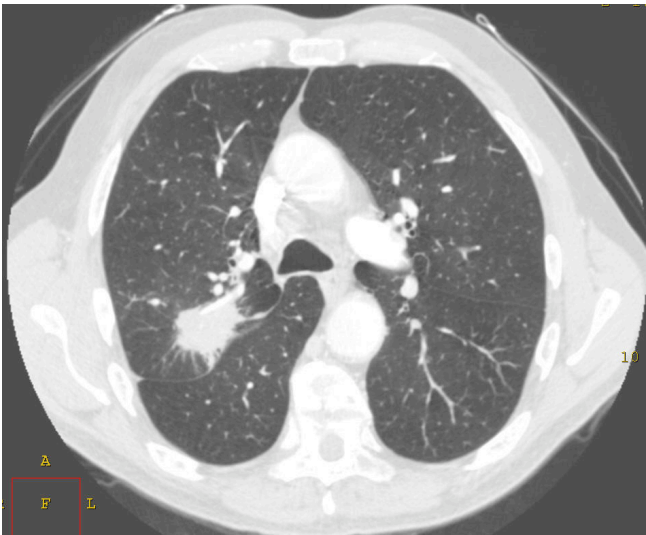


Fig 3. A spiculated mass is shown in the right upper lobe.

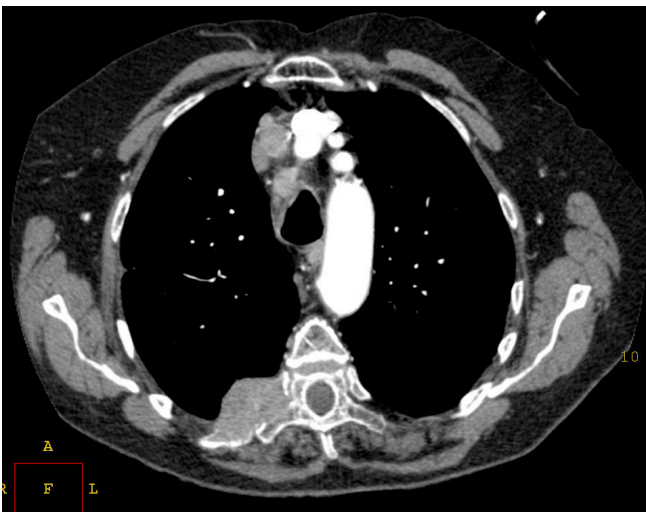


Fig 4a. A destructive lesion of the posteromedial aspect of the right rib is present.

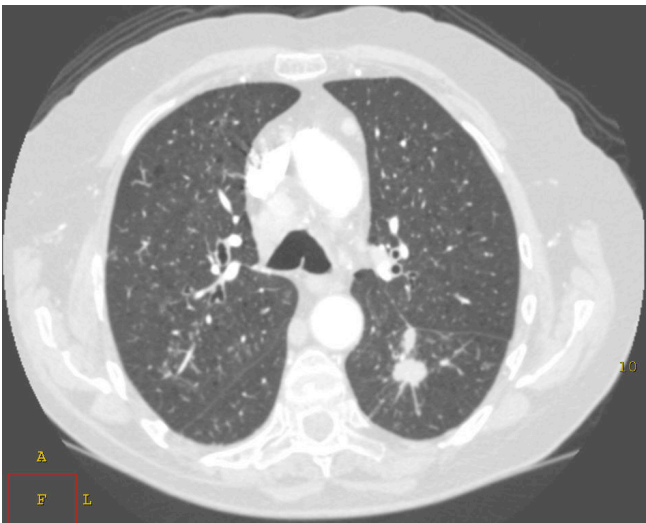


Fig 4b. Lung window settings in the same patient demonstrates a spiculated mass in the left lower lobe.

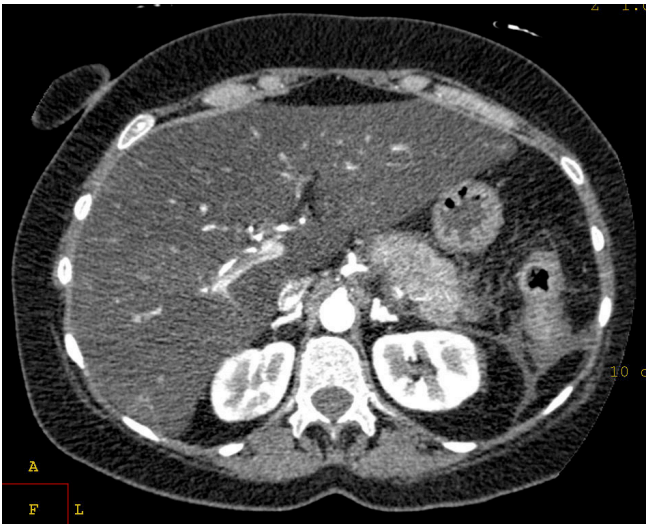


Fig 5a. Upper abdominal organs visible on the CTPA scan range demonstrate stranding of the peripancreatic fat with fluid in the left paracolic gutter, suggestive of pancreatitis.



Fig 5b. An oblique coronal reformat from an additional upper abdominal range performed immediately after the CTPA demonstrated peripancreatic inflammation consistent with pancreatitis.

arteries due to the patient performing the Valsalva manoeuvre during image acquisition, thereby reducing systemic venous return (n=2). No comment was made on the technical adequacy of the study in 112 patients (56%).

CONCLUSIONS

The prevalence of PE, as demonstrated by CTPA, in our reviewed sample was 28.3%, compared with a reported prevalence, demonstrated in the majority by pulmonary angiography, ranging between 19% and 79%¹⁰. Secondary findings were found in 56.6% of scans, highlighting the usefulness of CTPA in providing more thorough information in the majority of patients, as well as demonstrating pathology that was unsuspected or which required further individual management in 17 patients (9%).

A negative D-Dimer result, categorised as less than 250 in our institution, correlated with a negative CTPA in the 7 patients

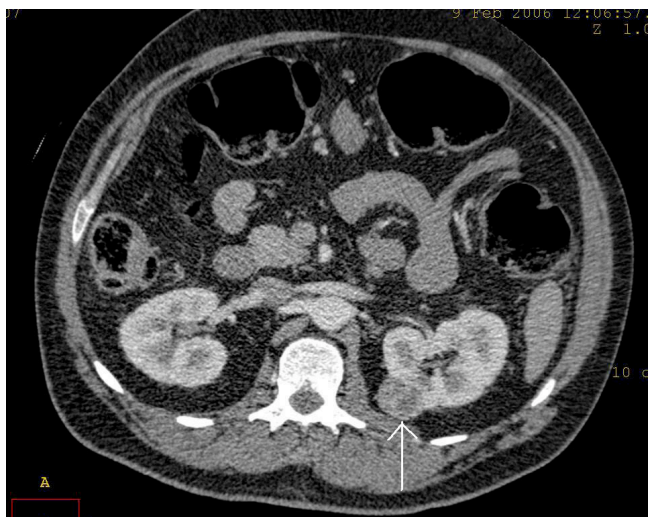


Fig 6. Additional upper abdominal scan range demonstrates a left-sided solid renal lesion.



Fig 7. Coronal reformat image of the lungs showing nodular circumferential pleural thickening.

in which it occurred, which confirms its use combined with clinical scoring as a useful pre-imaging tool to assign risk. Although the numbers in this review are too small to assign significance to a negative D-Dimer, they are in concordance with the known high negative predictive value of this test¹¹. When greater than 250, the absolute D-Dimer level does not appear to be helpful, as pulmonary emboli were seen with relatively low titres (371 being the lowest in this sample), and high titres (greater than 1000) were seen in patients with no PE demonstrated by CTPA. The lower titres seen may reflect the timing of D-Dimer estimation in relation to the onset of symptoms, as D-Dimer estimation may have taken place after the blood levels had “peaked”.

It is clear that a good CTPA study is dependent on a number of technical factors, including the parameters used for image acquisition and the adequacy of the opacification of the pulmonary arteries, which itself is dependent on a number of factors. In reviewing our reports, no mention of the adequacy of the examination was made in the majority (56.6%), a figure which could be significantly improved upon. If the scan was reported as being of limited adequacy, a reason was generally given in the report.

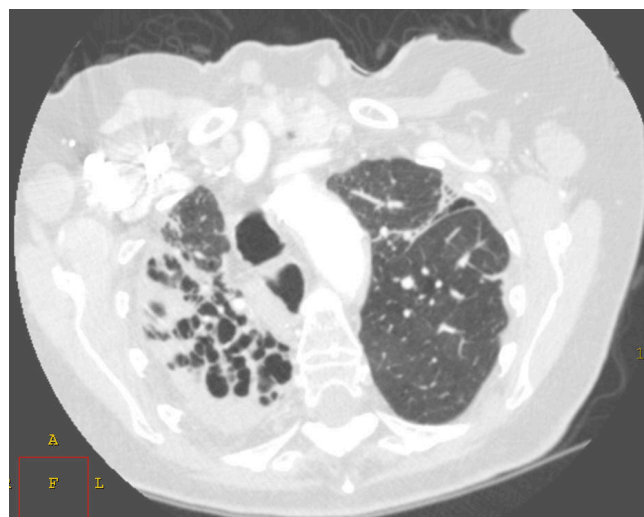


Fig 8. Right upper lobe fibrosis and cystic change with air/fluid levels.

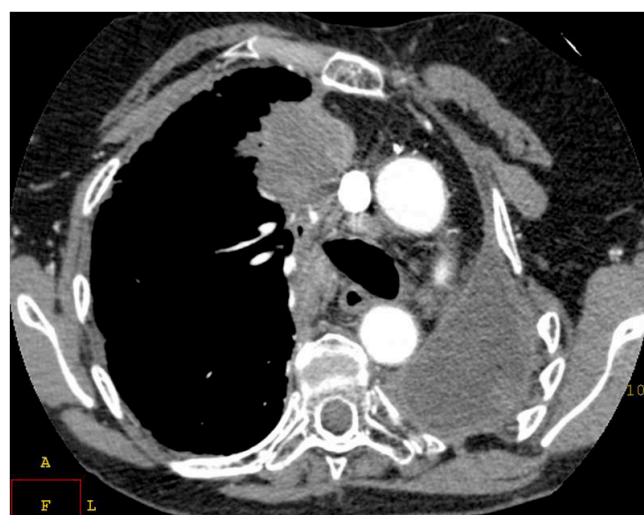


Fig 9. Fluid-filled left thoracic cavity in keeping with a left pneumonectomy. A right-sided mass lesion is seen.

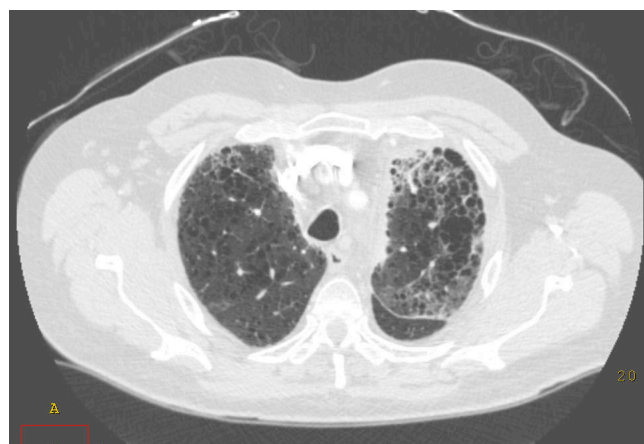


Fig 10. Bilateral apical interstitial fibrosis and cyst formation.



Fig 11a. Filling defect in the superior vena cava.

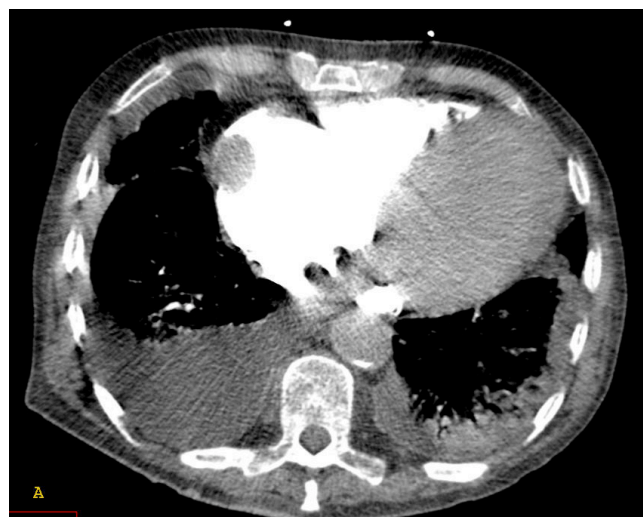


Fig 11b. Filling defect in the right atrium.

In highlighting the value of CTPA, not only in the detection of PE, but in providing information on other concurrent chest and occasionally upper abdominal pathology, our review demonstrates that careful evaluation of the other visualised structures, including the lung parenchyma, mediastinal structures, bony skeleton and visualised upper abdominal structures, is necessary to provide a comprehensive assessment of the study and may provide information to the clinician about processes that were not suspected and which may need action that would not otherwise have been effected.

The authors have no conflict of interest.

REFERENCES:

1. Fedullo PF, Tapson VF. The evaluation of suspected pulmonary embolism. *N Engl J Med* 2003;**349**(13):1247-56.
2. Patel S, Kazerooni EA, Cascade PN. Pulmonary embolism: optimization of small pulmonary artery visualisation at multidetector-row CT. *Radiology* 2003;**227**(2):455-60.
3. Stein PD, Terrin ML, Hales CA, Palevsky HI, Saltzman HA, Thompson BT, *et al*. Clinical, laboratory, roentgenographic, and electrocardiographic findings in patients with acute pulmonary embolism and no pre-existing cardiac or pulmonary disease. *Chest* 1991;**100**(3):598-603.
4. Wells PS, Anderson DR, Rodger M, Stiell I, Dreyer JF, Barnes D, *et al*. Excluding pulmonary embolism at the bedside without diagnostic imaging: management of patients with suspected pulmonary embolism presenting to the emergency department by using a simple clinical model and d-dimer. *Ann Intern Med* 2001;**135**(2):98-107.
5. Remy-Jardin M, Remy J, Artaud D, Deschildre F, Duhamel A. Peripheral pulmonary arteries: optimization of the spiral CT acquisition protocol. *Radiology* 1997;**204**(1):157-63.
6. Russo V, Piva T, Lovato L, Fattori R, Gavelli G. Multidetector CT: A new gold standard in the diagnosis of pulmonary embolism? State of the art and diagnostic algorithms. *Radiol Med (Torini)* 2005;**109**(1-2):49-63.
7. Winer-Muram HT, Rydberg J, Johnson MS, Tarver RD, Williams MD, Shah H, *et al*. Suspected acute pulmonary embolism: evaluation with multi-detector row ct versus digital subtraction pulmonary arteriography. *Radiology* 2004;**233**(3):806-15.
8. Campbell IA, Fennerty A, Miller AC. British Thoracic Society Standards of Care Committee Pulmonary Embolism Guideline Development Group. British Thoracic Society guidelines for the management of suspected acute pulmonary embolism. *Thorax* 2003;**58**(6):470-83.
9. American College of Emergency Physicians Clinical Policies Committee; Clinical Policies Committee Subcommittee on Suspected Pulmonary Embolism. Clinical policy: critical issues in the evaluation and management of adult patients presenting with suspected pulmonary embolism. *Ann Emerg Med* 2003;**41**(6):257-70.
10. Hogg K, Brown G, Dunning J, Wright J, Carley S, Foex B, Mackway-Jones K. Diagnosis of pulmonary embolism with CT pulmonary angiography: a systematic review. *Emerg Med J* 2006;**23**(3):172-8.